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METEO FRANCE
À VOS CÔTÉS, DANS UN CLIMAT QUI CHANGE

Verification of ISSR forecasts for contrail avoidance applications

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Introduction

CONTEXT **CICONIA** SESAR project

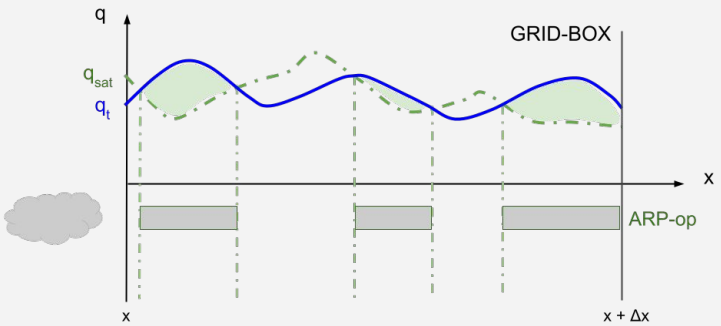
AIM Offer weather information regarding potential formation of **persistent contrails**

Two main challenges

1

A NWP model that **forecasts** Ice Supersaturated Regions, **ISSRs** (RH_{ICE} > 100%).

Cloud formation in the global NWP ARPEGE model of Météo France.



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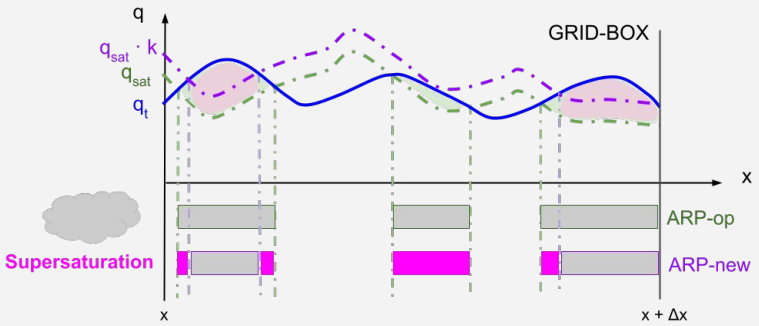
Modification of the ARPEGE model to allow ice supersaturation in the cloud scheme (**ACP - Arriolabengoa et al., 2025**).



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2

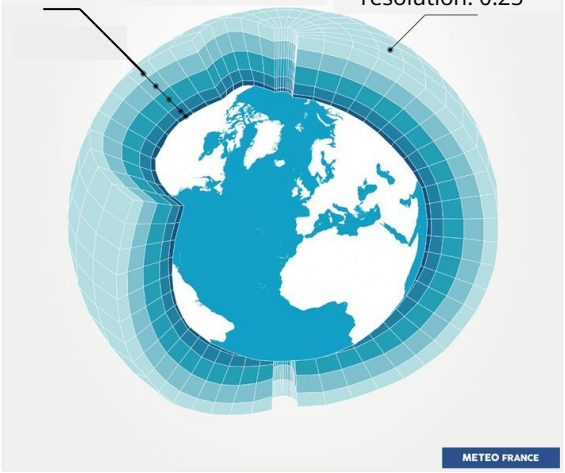
Interpretable **verification metrics** to assess the quality of the forecast.

Dataset

NWP data
ARPEGE

Vertical grid: FL250/FL450 - vertical step 1000ft

Horizontal grid resolution: 0.25°



Matching method

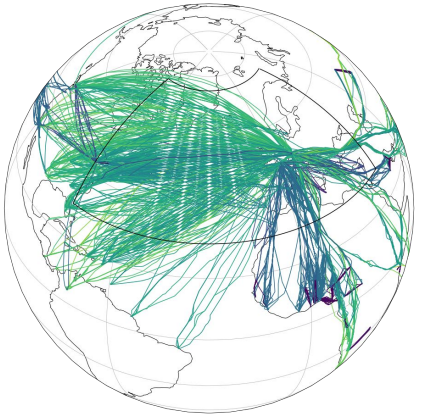
Nearest grid point
(horizontal, vertical, temporal)

Domain: **Europe & North Atlantic**

Time period: 01/07/2022 - 30/06/2023 (**1 year data**)

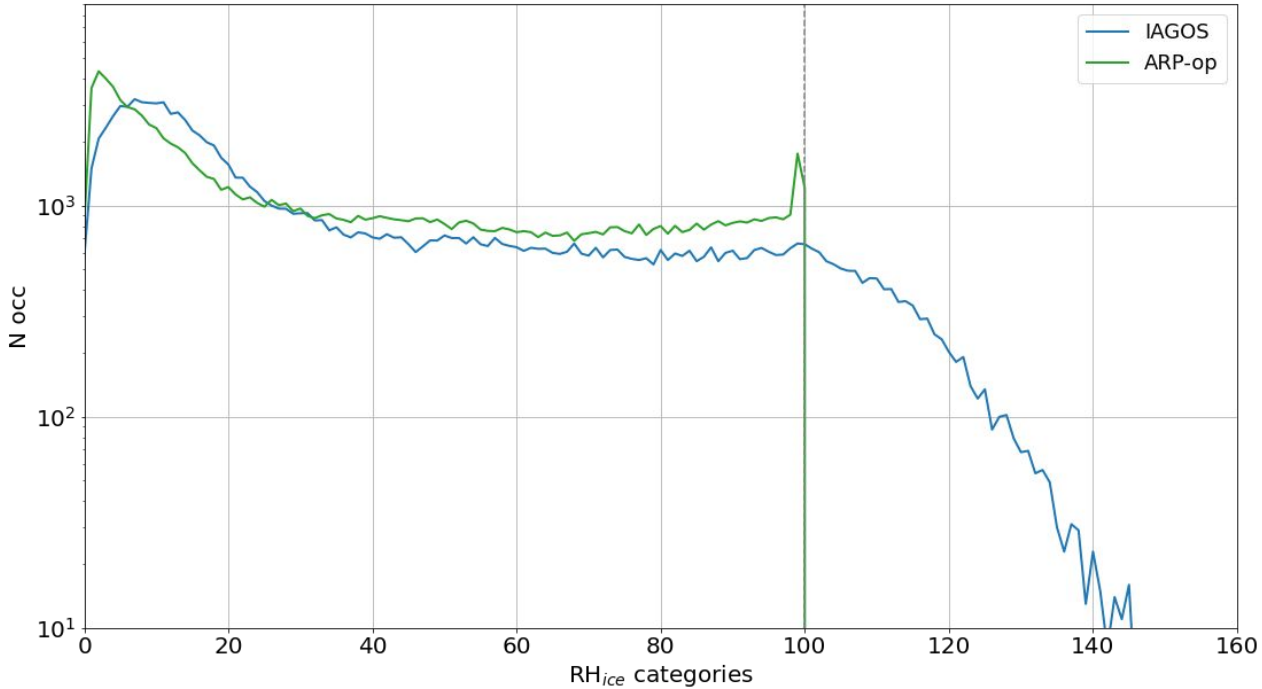
Observations

IAGOS data
in-situ temperature and humidity observations



~1E5 observations

Distribution of RH_{ice}



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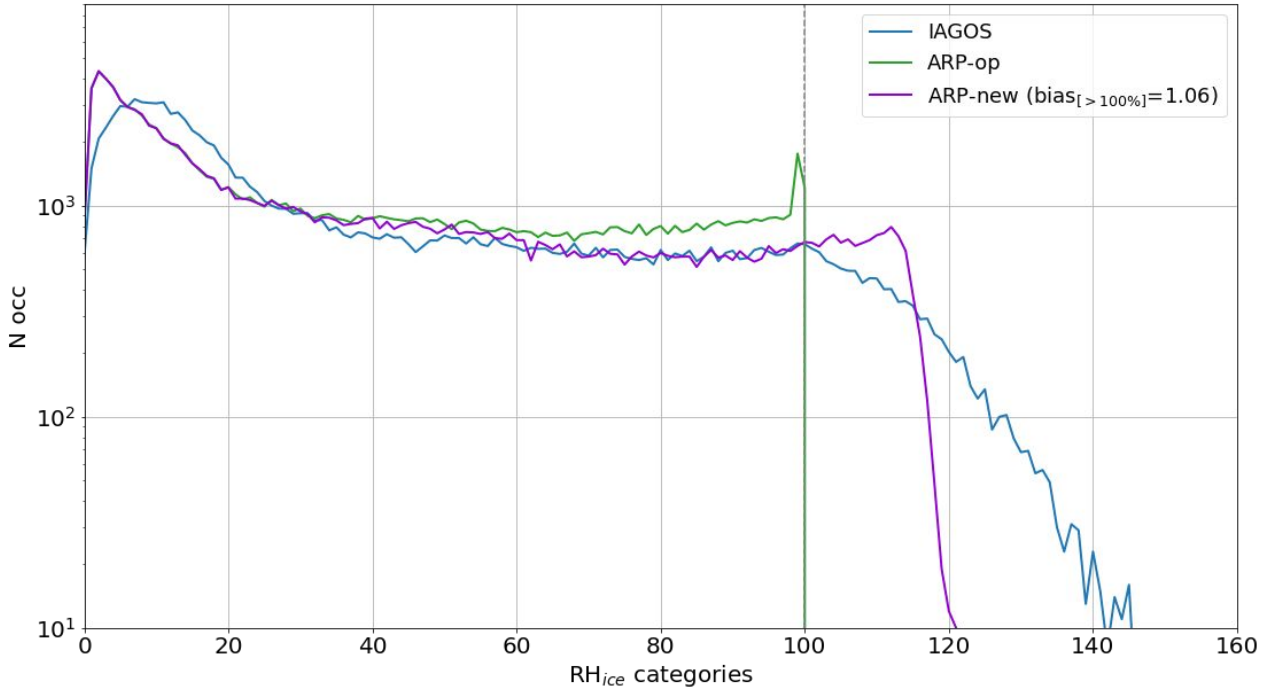

Statistical verification

Point-by-point metrics:

- Hit Rate = 53%
- False Alarm Ratio = 49%

Not realistic to expect grid-scale accuracy

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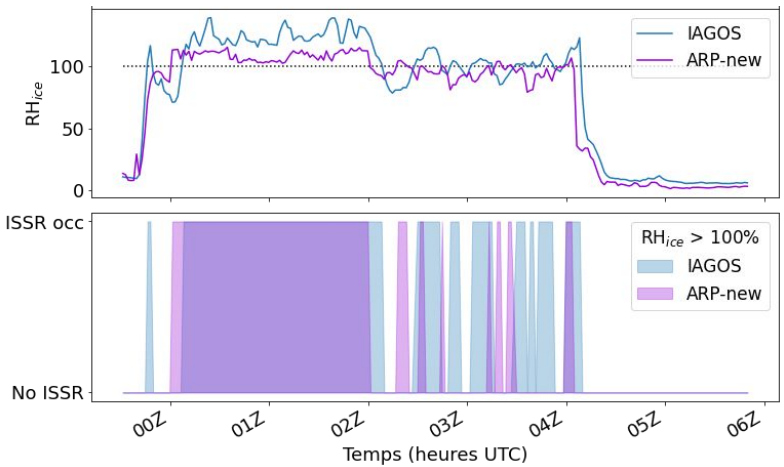
- **Uncertainties in**
  - accuracy of the **observations**.
  - forecast and observation **matching method.**
- Presence of **small-scale variability**.
- **Double penalty**: degraded metric values.



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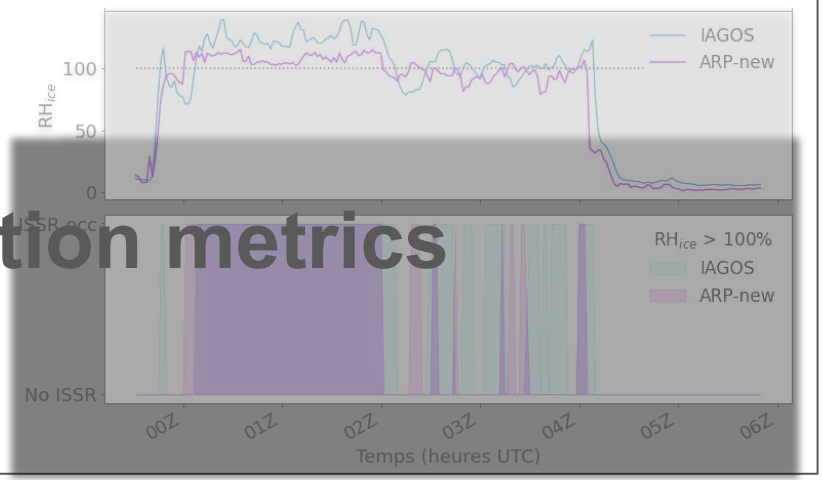
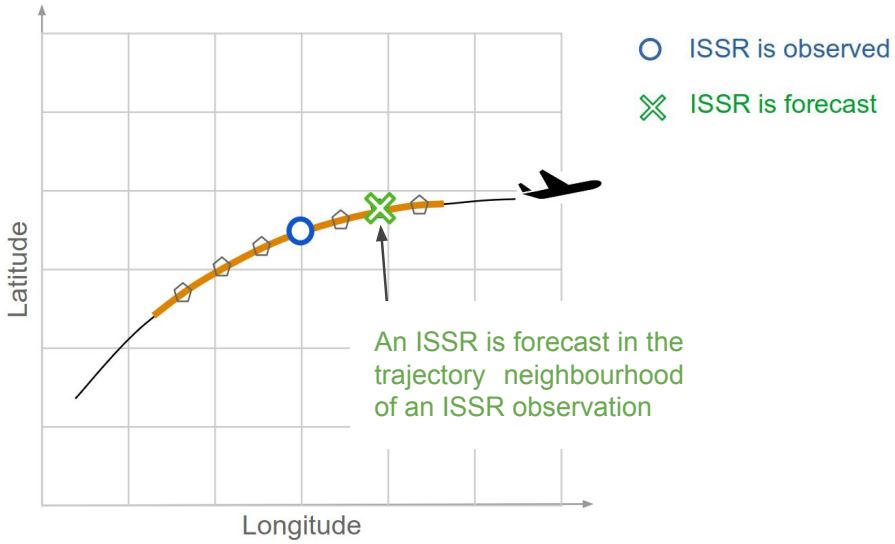
Spatial verification metrics



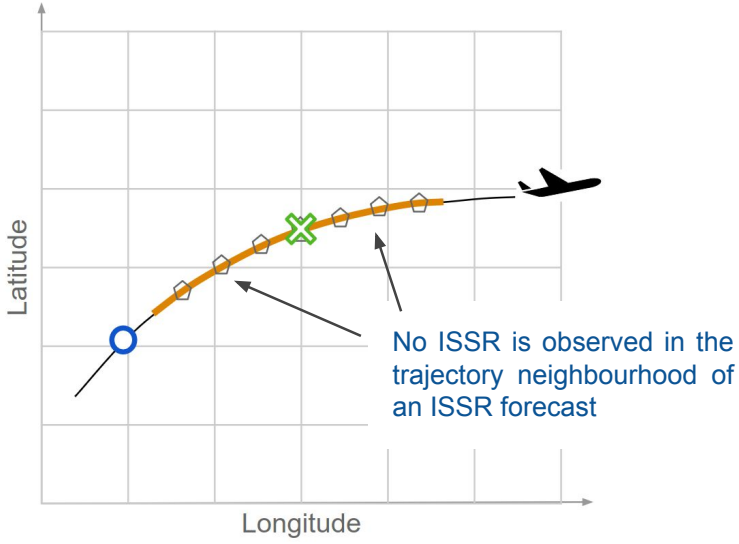
Statistical verification

Neighborhood tolerance upstream and downstream of the flight path

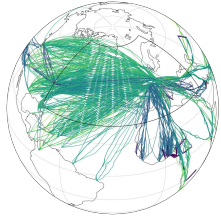
Hit

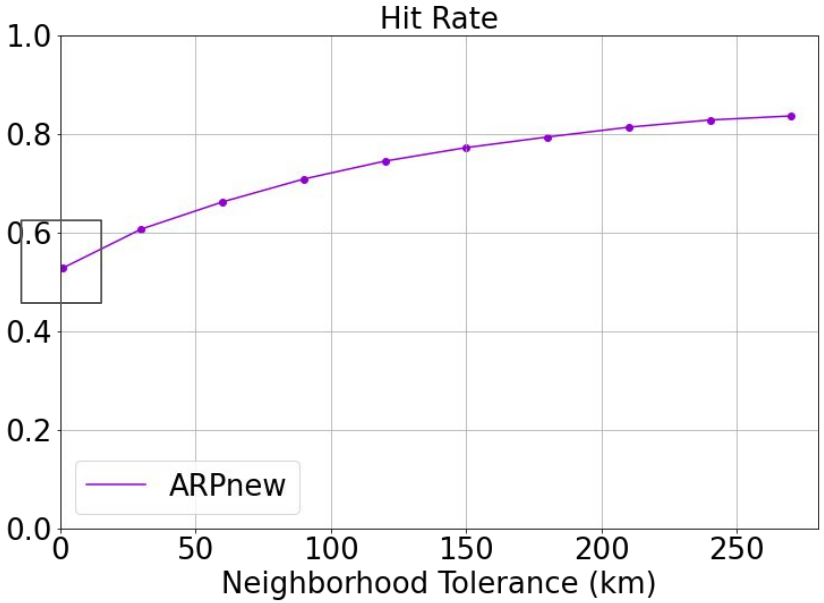


False Alarm (FA)

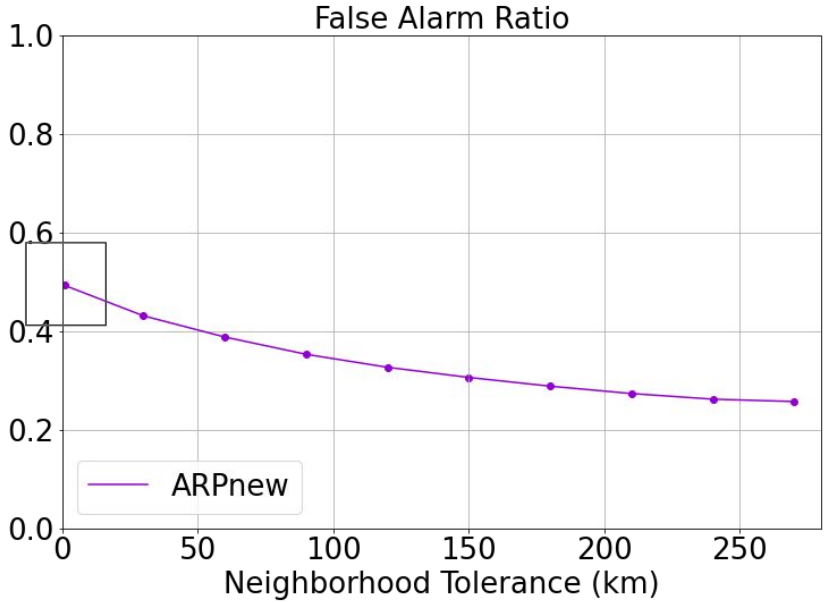


ISSR verification



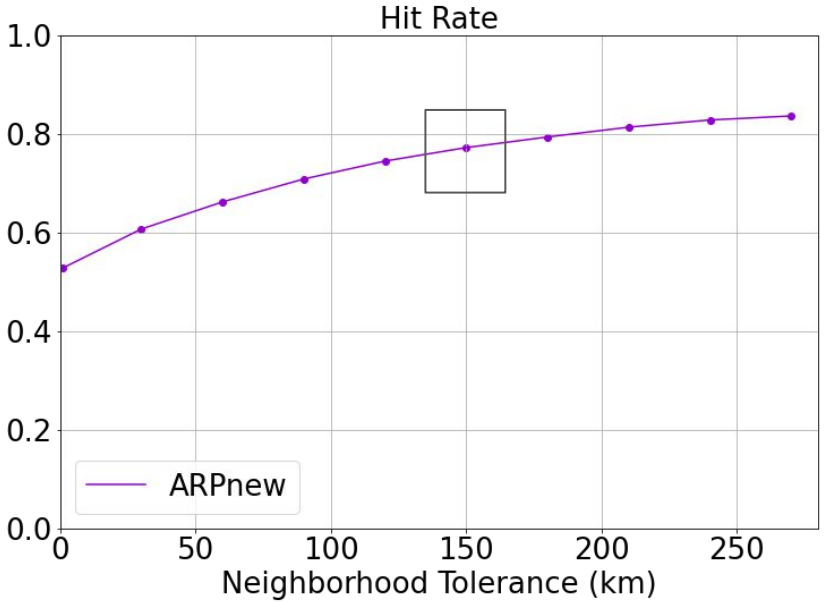


When an ISSR was observed, an ISSR was forecast in the nearest point in **53%** of the cases.

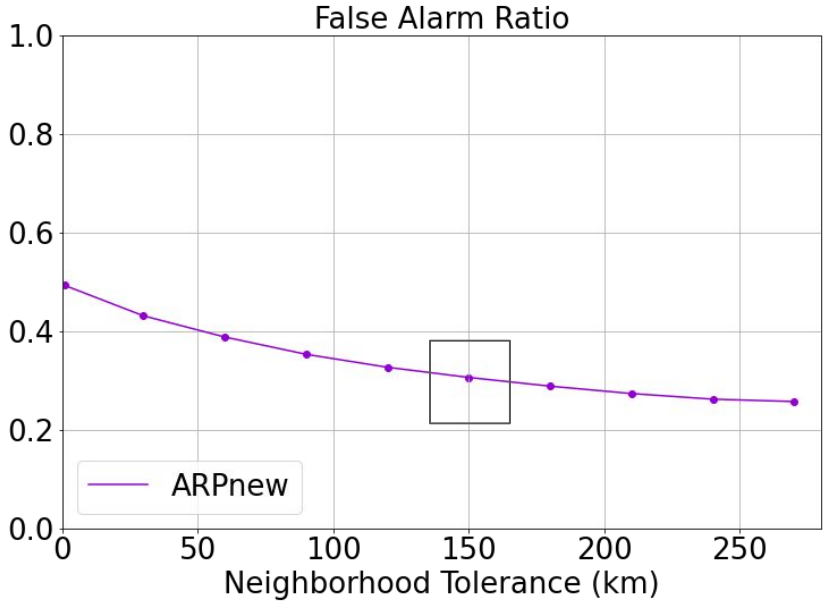


When an ISSR was forecast, no ISSR was observed in the nearest point in **49%** of the cases.

ISSR verification

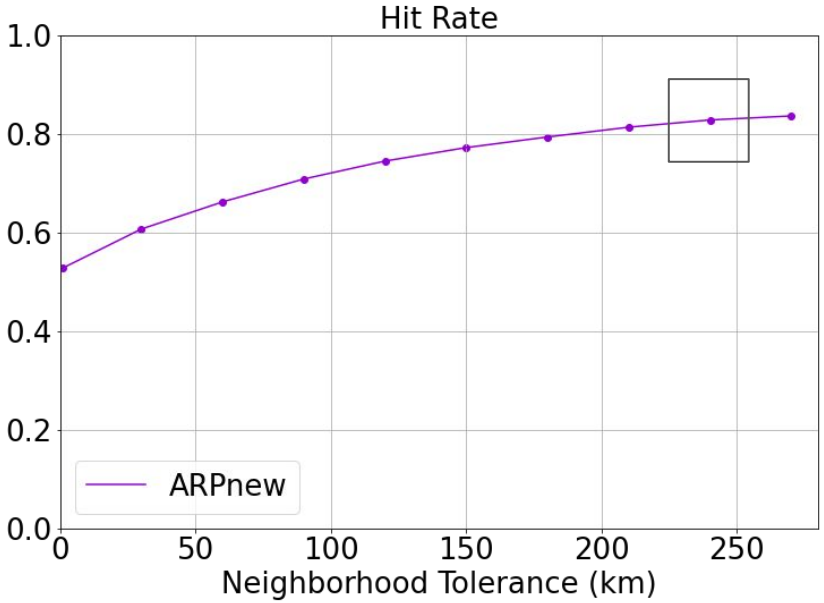


When an ISSR was observed, an ISSR was forecast in a 150 km (10 min) neighbourhood in **77%** of the cases.

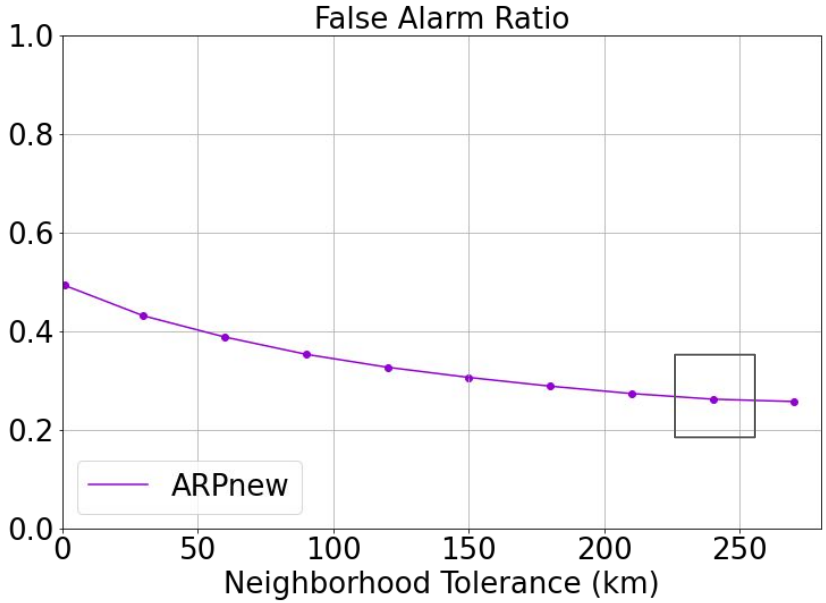


When an ISSR was forecast, no ISSR was observed in a 150 km (10 min) neighbourhood in **31%** of the cases.

ISSR verification



When an ISSR was observed, an ISSR was forecast in a 240 km (10 min) neighbourhood in **83%** of the cases.



When an ISSR was forecast, no ISSR was observed in a 240 km (10 min) neighbourhood in **26%** of the cases.

Interpretation of the results

with a neighbourhood tolerance of 150 km (~10 min)

HIT RATE	❏ 80% of the observed ISSRs have a predicted ISSR around the observation. ❏ 20% of observations not detected.
FAR	❏ 70% of ISSR forecasts are confirmed by an observation in the vicinity. ❏ 30% of forecasts without observations in the vicinity.

The ISSR observations and ISSR forecast are in close proximity to each other: **good spatial correspondence**.

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Contrail avoidance applications

1. **Avoiding with a margin** of 150 kms an ISSR forecast:
   - ❏ could ensure ~80% avoidance of all ISSRs.
   - ❏ being justified in ~70% of cases.
2. Including detection and false alarm estimates to **cost/lost metrics** in the evaluation of climate impact.

Dataset

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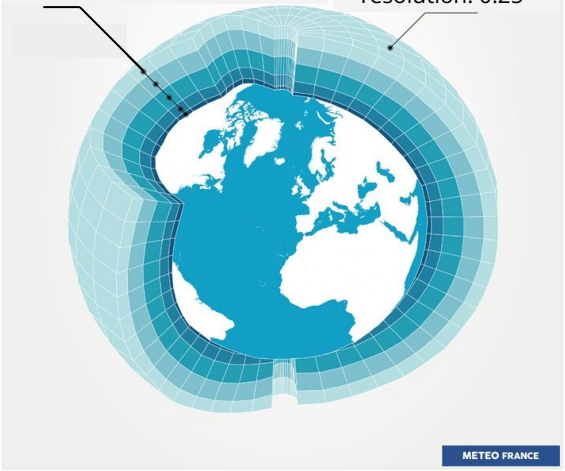
Horizontal grid resolution: 0.25°



Matching method

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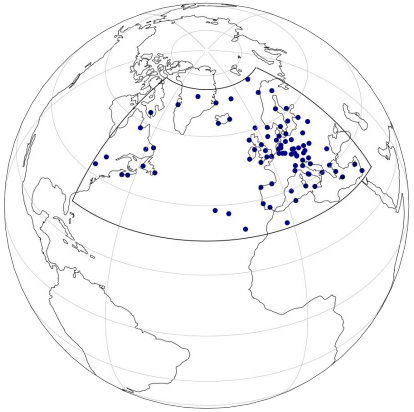
Time period: 01/07/2022 - 30/06/2023 (**1 year data**)

Observations

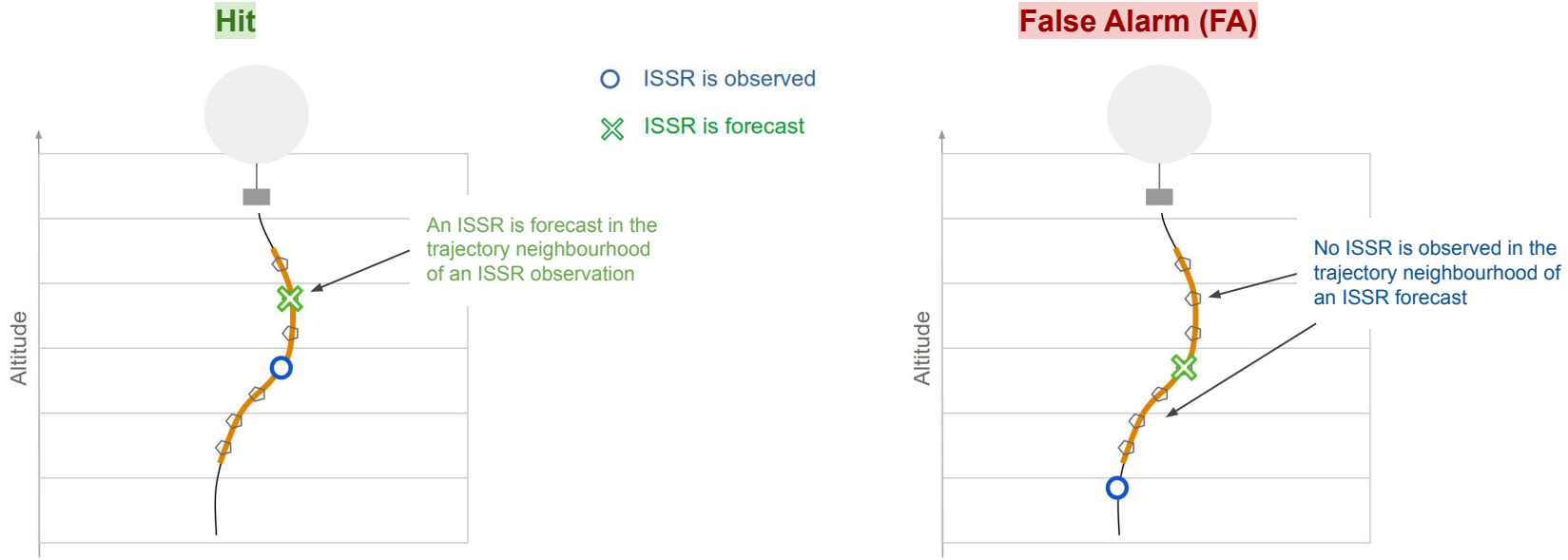
Radiosonde data
height profiles of temperature and RHice from Vaisala RS41



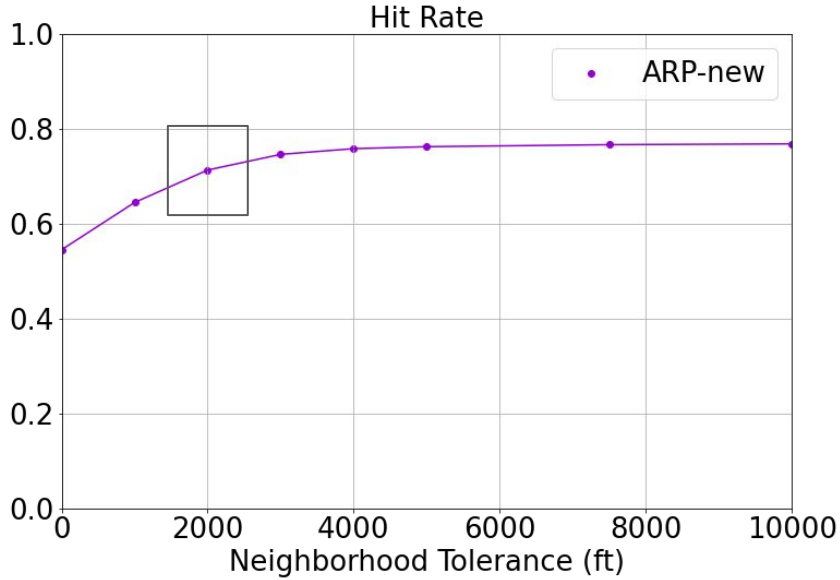
~1E6 observations

Statistical verification on the vertical profile

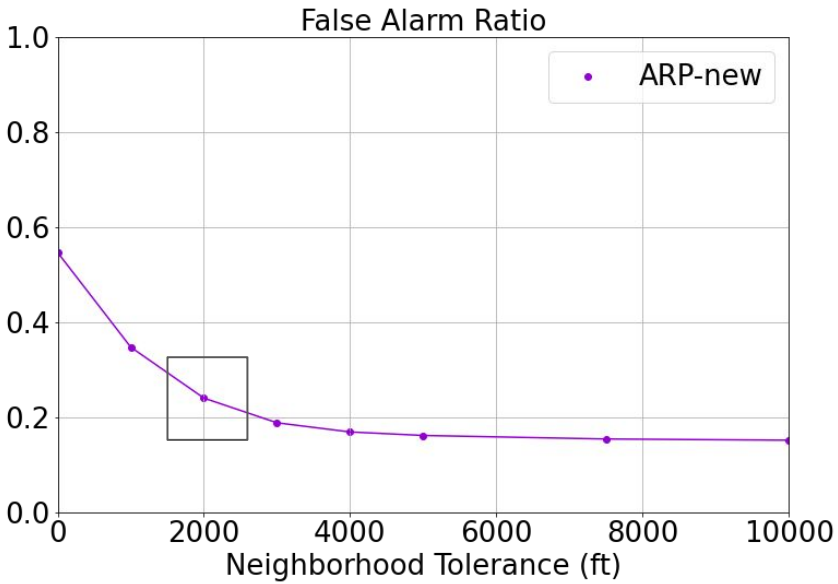
Neighborhood tolerance upstream and downstream the **radiosonde height profile**



ISSR verification



When an ISSR was observed, an ISSR was forecast in a 2000 ft neighbourhood in **71%** of the cases.



When an ISSR was forecast, no ISSR was observed in a 2000 ft neighbourhood in **24%** of the cases.

Take away

- Using **spatial verification metrics**
  - allows to address **uncertainty** of observations and matching method.
  - takes into account the **spatial scales of the operational context**.
- We show that there is a **good spatial correspondence between ARPEGE and observations**:
  - in the horizontal with IAGOS.
  - in the vertical with radiosonde.

- For c**ontrail avoidance applications**, the scores:
  - can be interpreted in terms of avoidance margin.
  - can be included in cost/lost metrics.

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Questions?

Thank you

Contact: sara.arriolabengoa@meteo.fr

sesar JOINT UNDERTAKING

CICONIA

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